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VINEGAR FROM WASTE FRUITS

BY

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* Died July 1, 1917.

† In co-operation with office of Public Roads and Rural Engineering, U. S. Department of Agriculture.

VINEGAR FROM WASTE FRUITS*

By W. V. CRUESS

Fruit, unsuitable for sale fresh, for drying or for canning, may often be used for vinegar making or for the manufacture of acetic acid from which to produce acetone, used in the manufacture of high explosives. A ton of apples, grapes, or most deciduous fruits, will yield from 140 to 175 gallons of juice suitable for vinegar making. Oranges will yield about 100 to 125 gallons. Apples will yield about 75 pounds of acetic acid per ton, grapes about 150 pounds, and oranges about 50 pounds. At 15 cents per gallon, the vinegar from a ton of apples or grapes is worth approximately $23, and from a ton of oranges $15. Grapes contain nearly twice as much sugar as apples, and the vinegar is correspondingly stronger. The figures given are based on the assumption that the grapes are not diluted with water. At $2 per gallon for acetone, the acetone from a ton of apples is worth about $7, of grapes about $13, and of oranges about $4.50.

There is usually a local demand for vinegar and those having surplus fruit can make vinegar for their own and for their neighbors' use. It is often possible to build up a profitable local trade and then gradually increase the output, so that a business of considerable size can finally be established. Profits in vinegar making are moderate and the prospective manufacturer should realize this fact before undertaking it on a large scale. Acetone for explosives is also in demand, but its manufacture involves the installation of extensive equipment and it should, therefore, be undertaken only on a large scale and in a locality within easy reach of a large supply of cheap fruit. The Fresno and other vineyard districts have large amounts of cull and second-crop grapes and raisin seeds suitable for acetone production, while citrus districts like Redlands or Riverside have a large supply of cull oranges not utilized at present, but which are suitable for this purpose.

It is proposed here to discuss briefly the principles of vinegar manufacture rather than to describe large-scale equipment. If the principles are thoroughly understood, methods of applying them to large or small-scale manufacture can be devised. Acetone is produced by the destructive distillation of calcium or sodium acetate

* Supplementary to "Grape Vinegar" (Bull. 227, by F. T. Bioletti).

formed from acetic acid obtained by the distillation of vinegar. Vinegar making is, however, one of the principal steps in the process and should be well understood.

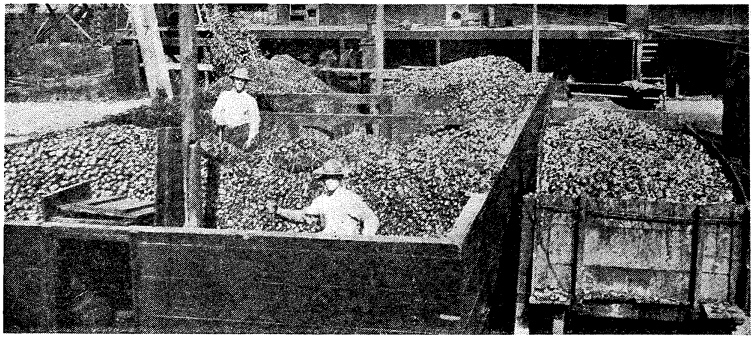

Fig. 1.—Waste apples, peels, and cores used in vinegar making.

Raw Materials.—Vinegar for table use requires fairly sound and clean fruit. For acetone manufacture, the condition of the fruit is not important. Any of the common California fruits, except lemons, can be used and also inferior dried fruits. Cannery waste, such as peels and cores, will make a satisfactory vinegar if clean; otherwise it may be used for acetic acid or acetone.

Crushing.—Crushers suitable for grapes and all varieties of fruits without stones are available in sizes varying from those suitable to a small kitchen to those having a capacity of 100 tons of fruit per day. The fruit should be thoroughly crushed to facilitate fermentation and pressing. Orange juice will ferment more satisfactorily if it is free from the oil of the skins. The oil may be recovered from oranges on a large scale by methods described in Department Bulletin 399 of the United States Department of Agriculture, Washington, D. C. The oranges may then be crushed after the oil cells are removed by the methods given in that bulletin.

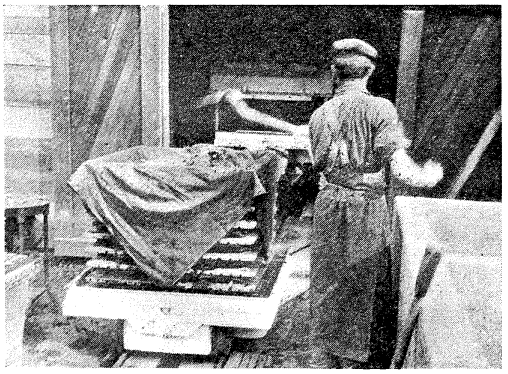

Fig. 2.—Filling a rack and cloth press.

Pressing before Fermentation.—If vinegar for table use is to be made from grapes, they should be pressed as soon as crushed to avoid color and an astringent taste from the skins and stems. Apples are usually pressed as soon as crushed, but a larger yield of juice is obtained and pressing is more complete if they are allowed to undergo a partial fermentation before pressing. Oranges and other fruits will press much more satisfactorily if fermented before pressing. Hand presses for small-scale operations may be had for about fifteen to twenty-five dollars. Larger presses to be run by hydraulic pressure will cost from $150 to $1000 or more. The basket and the rack and cloth types of presses are best suited to vinegar manufacture; the continuous press does not work so satisfactorily.

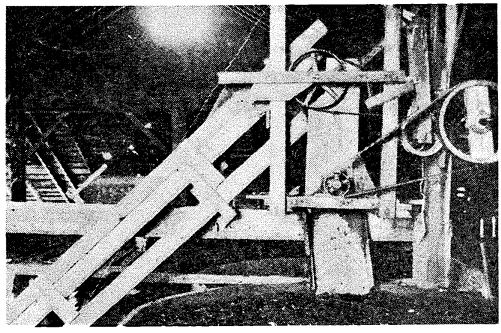

Fig. 3.—Elevator, crusher and vats for fermentation of crushed fruit before pressing.

ALCOHOLIC FERMENTATION

A. *Growth of Pure Yeast.*—The manufacture of vinegar requires two fermentation processes. The first causes the transformation of the sugar of the fruit or juice into alcohol. This is brought about by yeast. The second changes the alcohol into acetic acid and is caused by vinegar bacteria.

The alcoholic fermentation must be complete before the acetic or "vinegar" fermentation is allowed to start, or otherwise the yeast fermentation will be stopped by the acetic acid and unfermented sugar will remain in the vinegar. Such a condition results in weak vinegars of poor quality and low yields of acetic acid or acetone.

Alcoholic fermentation will occur naturally by the growth and activity of yeasts present on the fruits themselves. Such a fermentation is, however, very uncertain, usually very wasteful of sugar, and results in vinegars of varying and uncertain quality.

Selected pure yeast is necessary to insure uniform, complete fermentations, with maximum yields of alcohol and minimum waste of sugar. Pure yeast may be obtained for $1 per culture by writing to the Division of Viticulture, Hilgard Hall, University of California, Berkeley. The method of using the yeast is described below:

1. The yeast as received from the University is in solid form in a bottle plugged with cotton. A bottle of sterile fruit juice accom-

panies the yeast. Remove the cotton plug and fill the yeast bottle about three-quarters full with sterile juice from the other bottle. Replace the cotton plug at once.

2. Leave the yeast bottle in a warm place until the juice is fermenting rapidly, as indicated by the formation of gas bubbles. Three or four days are usually sufficient.

3. When the yeast is fermenting, sterilize three to five gallons of fresh juice by heating it to boiling in a covered agate ware or aluminum pot and let it cool overnight.

4. Then add the contents of the yeast bottle and mix the yeast and juice by pouring the juice back and forth a few times with a dipper sterilized by dipping in boiling water. Everything that comes in contact with the yeast or juice must be *scrupulously clean* and sterilized by boiling water or steam. Set aside in a warm place for three or four days. It will then be in vigorous fermentation. This will be enough to start 40 gallons of juice as described in step 5.

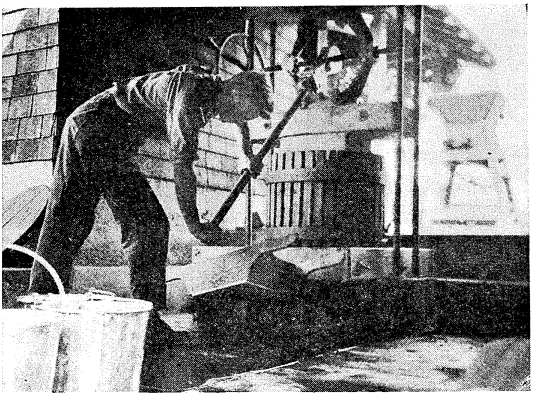

Fig. 4.—A small hand press.

5. Prepare a clean 50-gallon barrel for yeast growth by removing one head and washing the barrel out with hot water and "sal soda" or soda ash, followed by rinsing with boiling hot water. Heat about 40 gallons of juice to 165 degrees Fahrenheit or higher. This can be done by placing a steam hose in the juice in the barrel or by heating the juice in 5-gallon pots on a stove. A dairy thermometer may be used to test the temperature. Allow the juice to cool in the barrel to 90° F. or lower. Large tin buckets of cold water may be floated in the juice to cool it quickly. They must be *clean.*

6. When the juice has cooled, add the three or four gallons of fermenting juice previously prepared. Aerate and mix the yeast and juice in the barrel by pouring it back and forth with a dipper sterilized in hot water.

7. Aerate the juice five or six times daily in the same way until it is fermenting rapidly. This will be in three or four days. It is

then ready for use. This 40 gallons of yeast will be enough for 1000 to 2000 gallons of fresh juice. If more is needed, several more barrels of sterile juice may be started from the first barrel.

B. *Starting the First Fermentation Vats.*—1. As soon as the yeast is working rapidly in the yeast barrel, crush the fruit to be fermented. To each ton of crushed fruit add three-quarters of a gallon of 6 per cent sulfurous-acid solution and mix it in by stirring. This solution may be bought from the manufacturer for 20c to 25c per gallon. Potassium meta-bi-sulfite may be used instead, but at present is very expensive. A solution made by dissolving one pound in a gallon of water is used in the same way and the same amount as the 6 per cent sulfurous-acid solution.

Fig. 5.—Growing yeast in 50-gallon barrels. *a*. Barrels with sterilized juice. *b*. Barrels with yeast growing in juice.

If apples or grapes are being used, press them and transfer the juice to fermentation vats, tanks or barrels. Other fruits as soon as crushed are placed directly in the fermentation vessels. The pressed apple pomace is placed in a separate vat; it contains juice that may be recovered by pressing after fermentation.

2. A few hours after sulfiting, add five to ten gallons of the yeast to each ton of crushed fruit or each 200 gallons of juice and mix thoroughly.

3. If crushed fruit is being fermented, stir it once daily during fermentation to prevent molding and vinegar fermentation in the top of the fermenting mass.

C. *Starting Other Vats.*—When this first vat is in fermentation it may be used to start other vats. To the second vat add a half-gallon

of 6 per cent sulfurous-acid solution per ton of crushed fruit or per 200 gallons of juice. Then add 20 gallons of the rapidly fermenting juice or crushed fruit from the first vat per ton of crushed fruit and mix. When this vat is fermenting other vats may be started from it in the same way that the second was started from the first and the same system may be applied to all succeeding vats. If the yeast at any time seems to work poorly, a new start should be obtained from the University.

Pressed apple pulp or pomace is fermented by adding fermenting juice to it in a vat. Use about 10 gallons to each 100 gallons of pomace. It is pressed again after fermentation. A great deal of juice can be obtained in this way.

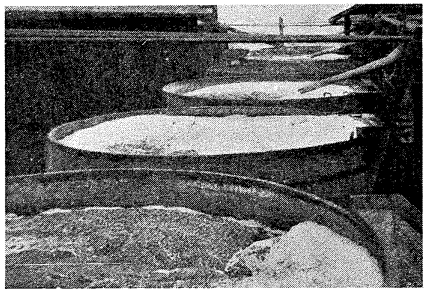

Fig. 6.—Vats of crushed fruit in fermentation.

D. *Pressing Fermented Fruits.*—If the fruits have not been pressed before fermentation they should be pressed after about four days' fermentation. Fermentation before pressing softens the fruit and greatly increases the yield of juice. Usually a great deal of the fermented juice may be drawn off before pressing so that only the residual pulp need be pressed. Press thoroughly and transfer the juice to tanks or barrels to finish fermenting.

E. *Completion of Fermentation.*—The juice is allowed to ferment until practically all of the sugar is converted into alcohol and carbonic acid gas. If conditions are favorable this will be in about three weeks or less. It is complete when there is no taste of sugar present and when gas is no longer given off. The progress of the fermentation can be watched by means of a Balling sugar tester or hydrometer. This instrument indicates approximately the amount of sugar present. The Balling hydrometer may be obtained from any chemical supply house directly or through a drug store for about 75c. A tall glass or tin cylinder will also be needed. To make the test pour the juice into the cylinder, insert the hydrometer and read the per cent of sugar indicated at the surface of the liquid.

The vats and all apparatus coming in contact with the juice should be clean. Each vat should be started with yeast from the preceding vat or from a pure-yeast apparatus as described above. If these precautions are observed good fermentations will result.

F. *Storage after Fermentation.*—The fermented juice should be allowed to settle for two to three weeks after alcoholic fermentation is over. This is to rid it of yeast and pulp, etc. During this settling process the tanks or barrels should be kept full to prevent growth of "wine flowers" on the exposed surface. Closed tanks should be employed.

G. *Racking.*—When the yeast and sediment has settled, the fermented juice must be "racked"; that is, drawn off from the sediment into other tanks or barrels. This can be done by means of a faucet near the bottom or by syphoning with a hose from the top and by pumping, or running by gravity into the new tanks, according to conditions and equipment. The sediment may be discarded, filtered or allowed to settle in barrels. By the last method more fermented juice may be recovered from the otherwise waste sediment.

If left in the juice, the sediment may give a bad flavor and interfere with acetic fermentation and the clearing of the vinegar.

DISTILLATION BEFORE ACETIC-ACID FERMENTATION

Where the fermented juice contains a great deal of suspended matter and where it is desired to make a vinegar of very high acid strength to be used in the manufacture of acetic acid or acetone, the fermented juice should be distilled. This will separate the alcohol from the impurities of the juice and a fairly high acetic acid can be made by passing this distilled liquid through generators. It is customary to carry out this distillation in large continuous stills which give a distillate of about 10 per cent alcohol. Distillation, however, is only used in large establishments and the equipment necessary is too expensive for the small-scale manufacturer. With the distillation process it is possible to recover all of the alcohol from the pressed fermented pomace by washing or leaching with water and then distilling the alcoholic wash. If fruits are to be used on a very large scale for the manufacture of acetic acid and acetone, it is recommended that the distillation process be installed because all of the alcohol is then recovered and a purer acid obtained.

ACETIC-ACID FERMENTATION

A. *Acidification.*—The transformation of the alcohol in the fermented juice is carried on by vinegar bacteria. They will not work efficiently and will not start quickly unless the fermented juice after alcohol fermentation is acidified and inoculated with vinegar bacteria. These two objects are accomplished by the addition of new vinegar to the fermented juice after it has been racked, or to the alcoholic distillate from the still. The fermented liquid should be acidified

with at least one gallon of strong new vinegar to each three gallons of the fermented juice. This new vinegar will carry with it large quantities of vinegar bacteria which will heavily inoculate the fermented juice and cause a rapid start of vinegar fermentation. After acidifying in this way, the vinegar fermentation is carried out by either one of the processes described below:

B. *Slow Process.*—The slow process is carried out in barrels or other containers and requires several months to a year for completion. It is greatly hastened by the addition of vinegar as noted under "A." If it is carried out in barrels, they should be filled about three-quarters full. The bung of the barrel should be removed and the bunghole covered with a wire screen or a cheesecloth to keep out insects. At each end of the barrel, slightly above the level of the liquid, two holes

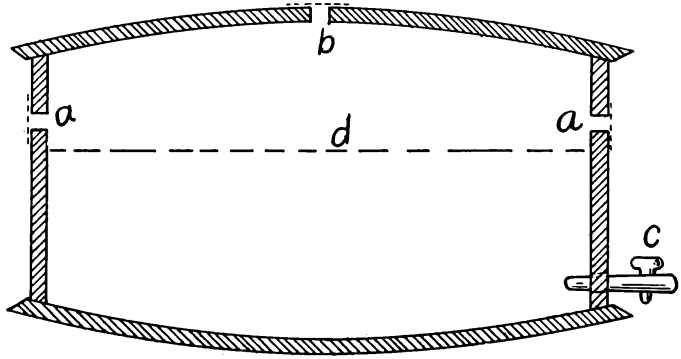

Fig. 7.—Barrel arranged for slow process of vinegar fermentation. *a.* Three-quarter inch holes at each end of barrel, covered with screen or cheesecloth. *b.* Bunghole. *c.* Wooden spigot. *d.* Level of vinegar.

should be bored each about one inch in diameter. These holes should also be screened to keep out vinegar flies, etc. The barrels should be kept in a warm place and should not be disturbed during the vinegar process. The vinegar is simply allowed to remain in the barrels until it has reached its maximum strength. About three-quarters of the vinegar can then be drawn off into other barrels and newly fermented and settled juice can be added to the remaining one-fourth of the vinegar. This new lot of fermented juice and vinegar is then allowed to acetify. This process can be repeated indefinitely, starting the new lot of fermented juice each time with one-fourth of the new vinegar left in the barrels. This method is known as the "Orleans" process and is the best of all slow processes. It is a mistake to simply allow the vinegar fermentation to depend on chance because great risk is run of having the vinegar completely

spoiled or of getting an inferior product. This is especially true of orange vinegar.

C. *Testing the Vinegar.*—The vinegar fermentation, whatever process employed, should be watched carefully by testing the acid strength from time to time. If this is to be done very accurately, a standard sodium-hydroxide solution and the necessary instruments should be obtained from a reliable chemical supply house which will furnish the equipment with instructions for use. The Leo Acid Tester is simpler and sufficiently accurate for factory use. This small instrument can be obtained from any of the chemical supply houses directly or through a local druggist. The cost is about five dollars or less. It gives the strength of the vinegar in "grains." The Pure Food Law requires that a vinegar shall have at least 4 per cent acid or be "40-grain vinegar." It can be above this and usually is if it is a pure vinegar. A good tester is necessary in the manufacture of any considerable quantity of vinegar. Directions accompany the Leo Tester. Bulletin 227 of this station also tells how to use it.

The vinegar fermentation should continue until there is no further increase in acid. This indicates that it is complete. A good cider vinegar should reach a strength of "60 grains." A wine vinegar should reach "75 to 100 grains." A good orange vinegar should reach at least "45 to 50 grains." A "distilled" vinegar made from an alcoholic distillate containing 10 per cent alcohol will reach "90 to 95 grains." A distilled vinegar can be made only by the generator process.*

D. *Generator Process.*—The rate of vinegar fermentation depends upon the amount of air supplied to the vinegar bacteria. Vinegar generators merely increase the amount of surface of vinegar exposed to the air. The surface is a great many times that which would be exposed in an ordinary barrel. Therefore, the rate of acidification is enormously increased. Most generators consist of an upright tower filled with beechwood shavings or other suitable material, such as rattan shavings or coarse coke or charcoal. For fruit juices, beechwood shavings will be found best. Figure 8 shows a plan of a generator.

To use the generator, it is first filled with clean beechwood shavings. The shavings are then wet by running strong new vinegar through them until they are saturated. The generator is equipped with a tilting trough *C* which distributes the vinegar over the head, from which it flows down over the shavings through numerous holes. This

* See also "Cider Vinegar by the Quick Process," published by the Hydraulic Press Mfg. Co., Mt. Gilead, Ohio. Sent free on application to above address.

vinegar should be run through the generator several times until the shavings are saturated. The alcoholic liquid which has been acidified with one-fourth its volume of new vinegar is then started slowly through the generator. The usual rate of flow is not more than 25 gallons per day of 24 hours. At first, the liquid issuing from the generator will not be strong vinegar, but after three or four days of running, the vinegar bacteria will multiply in the shavings sufficiently to cause a rapid fermentation so that finally the vinegar as it comes through at the rate of 25 gallons per day or less will come out vinegar of the maximum strength possible with the raw material being used. The rate of flow and the air supply which comes through the small inlets at the bottom of the generator are so regulated that a temperature of about 80 to 85 degrees F. is maintained. A thermometer, inserted as shown in the drawing, near the center of the generator, will indicate the temperature.

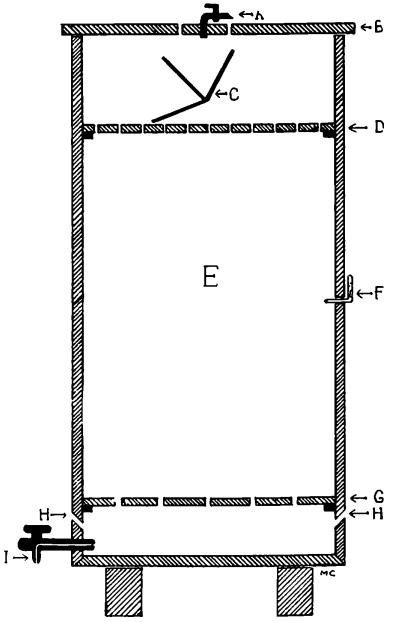

Fig. 8.—Upright generator. *A*. Supply pipe. *B*. Cover. *C*. Tilting trough. *D*. False head. *E*. Main chamber filled with shavings. *F*. Thermometer. *G*. False bottom to support shavings. *H*. Air inlets. *I*. Outlet.

With clear juice and careful manipulation, the generator can be kept running for six or seven months without cleaning. It will in time, however, become clogged with sediment so that it will not act

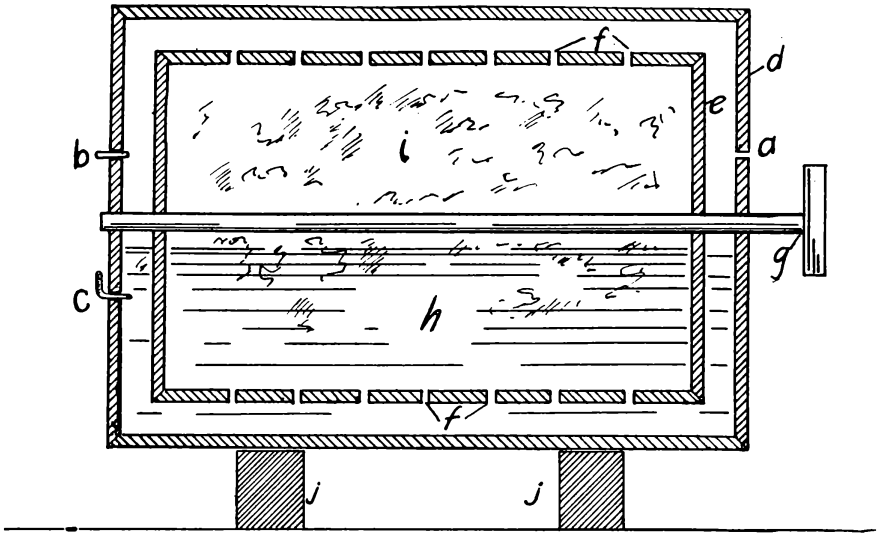

Fig. 9.—Revolving generator for factory use. *a*. Air inlet. *b*. Air inlet with regulating wooden plug. *c*. Thermometer. *d*. Wall of outer chamber which encloses cylinder *e*. *e*. Revolving cylinder filled with beechwood shavings. *f*. Air inlets to *e*. *g*. Shaft and pulley to rotate *e*; *e* rotates about once per hour. *h*. Liquid, usually about 500 gallons. *i*. Beechwood shavings. *j*. Supports for generator.

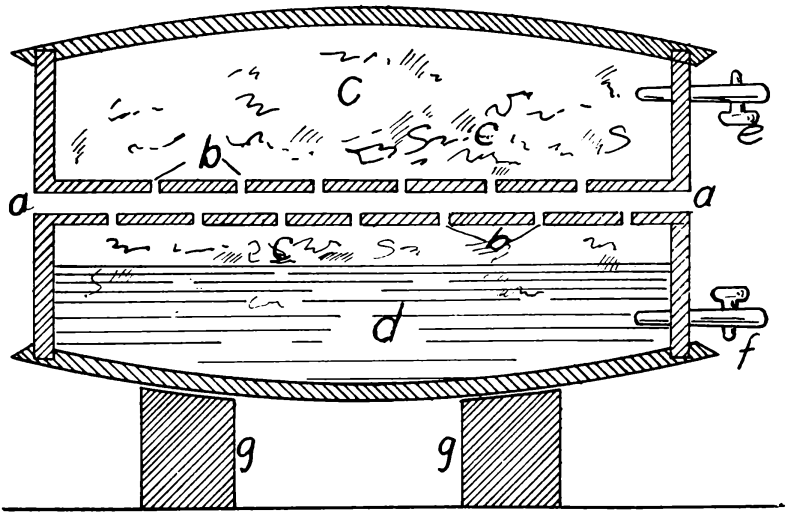

Fig. 10.—Rotating generator made from barrel filled with beechwood shavings. *a*. Air inlets at ends of barrel. *b*. Wooden partitions in barrel perforated to allow passage of air. *c*. Shavings. *d*. Vinegar. *e*. Upper spigot, open. *f*. Lower spigot, closed. As barrel rotates *f* becomes upper and *e* lower spigot. *g*. 3 × 6 inch skids for barrel.

efficiently. It must then be stopped and the shavings washed in hot water. They can then be dried in the sun and returned to the generator. The filled generator should never be stopped for more than twenty-four hours at a time because the shavings will become diseased and moldy if the generator is not kept in operation.

A type of generator that need not be cleaned so often is the horizontal revolving type. This generator consists of a cylinder filled with shavings. It is enclosed in a wooden air-tight box with air inlets. The lower half of the cylinder is immersed in acidified fermented juice, the upper half is exposed to the air. The cylinder rotates slowly. Acetification takes place in the exposed upper half. The temperature is maintained at 80–85 degrees F. by regulating the air inlets and rate of turning. The generator usually holds about 500 gallons (see fig. 9). A simple form of rotating generator is a barrel filled with shavings. Air vents are made in the centers of the heads of the barrel. It is filled half full of acidified fermented juice. It is turned half way over several times daily to expose new shavings to the air (see fig. 10).

Distilled vinegar, which is made from an alcoholic distillate of fermented fruit juice or other material, is made in generators filled with beechwood shavings, or, better, with pieces of charcoal or coke. Charcoal and coke cannot be used for undistilled fruit juices because they soon become inactive through the accumulation of sediment.

Aging.—When the vinegar has reached its maximum strength, either by the slow or the generator process, it must be aged before it is at its best quality for table use. The aging process takes place during storage and results in an improvement in flavor and in clearness. The best vinegar is aged at least a year before it is put on the market. The aging should take place in tanks or in barrels which are kept full and closed.

CLARIFICATION AND FILTRATION

Well made vinegar from good material will very often clear sufficiently during the aging process to make it suitable for bottling. Usually, however, it will be necessary to aid the clearing by filtration or by the addition of some clarifying substance.

A. *Clarification.*—Two substances are in common use for the clarification of vinegar, viz., fish isinglass and Spanish clay. Isinglass is the more expensive, but produces the most perfect clearness. The usual amount of isinglass necessary to clarify cider vinegar is about one ounce per hundred gallons, although this will vary considerably

with the condition of the vinegar. The isinglass is weighed out and broken up into small pieces. It is then mixed with one gallon of vinegar for each ounce of isinglass. It is allowed to soak until the isinglass becomes swollen and soft. Warming the mixture will aid in dissolving the isinglass. The isinglass is then broken up very thoroughly and mixed with the vinegar until a solution free from lumps is obtained. The mixture should be passed through a fine sieve and the lumps retained well broken up. This solution of isinglass is then added to the vinegar at the rate of one gallon for each hundred gallons of vinegar to be clarified. It must be emphasized that the isinglass must be made into a very smooth solution

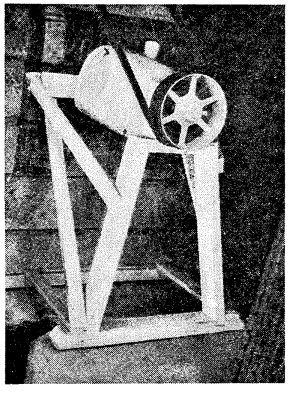

Fig. 11.—A small barrel arranged to mix clay, or other clarifying agent, and water by agitation.

before it is used. Otherwise, the clarification will be imperfect. The vinegar and isinglass are then mixed thoroughly in a barrel or tank by stirring. The mixture is allowed to stand until the isinglass settles, leaving a clear liquid above. The clear vinegar can then be drawn off with a hose or from a faucet. The sediment can be drained off and filtered.

Spanish clay is used in a similar way. It is mixed with water at the rate of one pound to each gallon of water, and allowed to soak for several days until it becomes soft. It is then worked up with the hands or by continuous agitation to give a thin, smooth mud or suspension of clay. The clay must be broken up very finely. The device shown in fig. 11 shows a convenient method of mixing the clay and water in a rotating ten-gallon barrel.

They are placed in this barrel which is set rotating slowly. Within a few hours the mixing is complete. For each 100 gallons of vinegar to be clarified, the amount of clay will be from three to six pounds; that is, from three to six gallons of the one pound per gallon clay solution. This solution is mixed with the vinegar by stirring and is allowed to settle in the same way as directed for isinglass.

The amount of clay to be used will vary with the cloudiness and condition of the vinegar. Where an attempted isinglass clarification has failed the vinegar can be treated successfully with Spanish clay later, or often isinglass and clay may be added together with good results.

B. *Filtration.*—Where large amounts of vinegar are to be made, clarifying often becomes impracticable and filtration is resorted to because of its cheapness and because very large volumes can be handled rapidly. Any of the standard types of filters, such as the Karl Kieffer, the International, or the Seitz Filter, can be used successfully for vinegar, if the interior of the filter is heavily coated with tin to protect it from the action of the acid. For small-scale operations, a cloth bag filter, costing five to ten dollars, can be used. The efficiency of the bag filter is increased if a small amount of infusorial earth (Kieselguhr) is added to the vinegar before filtration.

Bottling.—For bottling purposes vinegar should be aged and perfectly bright. If the operations previously described have been carried out successfully, the vinegar will be in this condition. Bottles should be filled full and well corked so that bacteria will not grow in the vinegar and cause it to become cloudy. Vinegar clarified with isinglass will remain bright in the bottles more satisfactorily than vinegar clarified with Spanish clay. Ordinary grape juice bottles or other type of Crown finish bottles make very satisfactory containers for vinegar, because the capping is less expensive and troublesome than corking and the appearance is attractive.

VINEGAR DISEASES

Lactic Bacteria.—Fermented fruit juices that have not been fermented with pure yeast usually develop lactic-acid bacteria. These bacteria are also known as "tourne bacteria" and are very common. They produce a disagreeable taste, cloudiness and lactic acid in the fermented juice. These persist in the vinegar and reduce its quality. The lactic-acid bacteria can be avoided if pure yeast and a small amount of sulfurous acid are used in the way described.

Wine Flowers.—If the fermented fruit juice is left in open tanks, it will become coated with "wine flowers," a form of wild yeast that destroys alcohol and flavor and causes cloudiness. It can be avoided by storing the fermented juice in filled and closed barrels or tanks and its development can be checked in open tanks by the addition of one gallon of new vinegar to each three gallons of fermented juice, as directed under vinegar fermentation.

Vinegar Eels.—Vinegar often becomes infested with small nematode worms known as "vinegar eels." These little eels are about an eighth of an inch long and can be seen by holding the vinegar in a glass to the light. They destroy the acid and are very unpleasant in appearance. If the fermented juice or vinegar in the factory becomes badly infested, all the juice and all of the tanks must be sterilized by heat to rid the factory of them. Vinegar infested with eels can be sterilized by heating to about 130 degrees F., at which temperature the eels are killed. Tanks and barrels that have been infested should be sterilized by steam. The same applies to generators which often become contaminated with this pest. A sterilizer can be made by surrounding a piece of tin pipe, 10 feet or more in length, with a steam jacket made of iron pipe. The vinegar or cider, etc., is passed through the tin pipe, which is heated by steam. The hot vinegar or fermented juice can be cooled by passing it through a coil of tin pipe immersed in water.

SUMMARY

1. Vinegar making depends on two fermentations. The first is fermentation of the sugar to alcohol and carbonic acid gas by yeast. The second is the transformation of the alcohol into acetic acid by vinegar bacteria. The fermentations must be kept separate and distinct to get good results.

2. Pure yeast and a small amount of sulfurous acid should be used to insure good alcoholic fermentation and to eliminate lactic bacteria.

3. Most fruits can be pressed most satisfactorily if crushed and fermented before pressing.

4. The fermented juice should be stored several weeks to rid it of yeast and other solid particles and should then be "racked" or drawn off the sediment before vinegar fermentation commences.

5. To the racked juice, should be added one-fourth its volume of new vinegar to start acetic fermentation and prevent vinegar diseases.

6. The acidified fermented juice may then be made into vinegar by the slow process in barrels or by the quick process in generators. Vinegar fermentation requires an abundance of air.

7. The progress of the acetification should be watched by the Leo tester or other means.

8. The vinegar should be aged for a year before sale if a high quality is desired.

9. Vinegar may be clarified by isinglass or Spanish clay, or by filtration.

10. Lactic-acid bacteria injure the quality of vinegar, but are avoided if pure yeast is used; wine flowers destroy alcohol, but are prevented if the fermented juice is acidified with one-fourth its volume of new vinegar; vinegar eels are destroyed by heating the fermented juice or vinegar to 130 degrees F.

Publications.—Write to the State Pure Food and Drug Laboratory, University of California, Berkeley, for a copy of the State Food and Drug Regulations.

Bulletin 213 and Circulars 119 and 140 of the Experiment Station, obtainable free of charge on written application to the Dean's Office, College of Agriculture, Berkeley, will be found of great assistance in the use of pure yeast and control of alcoholic fermentation.

A chapter in Marshall's Microbiology on vinegar manufacture, by Prof. F. T. Bioletti, may also be consulted.

STATION PUBLICATIONS AVAILABLE FOR FREE DISTRIBUTION

REPORTS

1897. Resistant Vines, their Selection, Adaptation, and Grafting. Appendix to Viticultural Report for 1896.
1902. Report of the Agricultural Experiment Station for 1898–1901.
1903. Report of the Agricultural Experiment Station for 1901–03.
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